LCA Discussions

System Boundaries According to Decision Scope: A Concept of Focal Zones *

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Abstract

Applying a "whole system model" in Life Cycle Assessment results in LCA being a tool for the best possible representation of the physical context of an analysed product. An implementation of LCA in decision making, however, has to consider the demands of the decision-maker; information of a kind that can be implemented in decision making has to be generated. Consequently, the system model has to reflect the operational context of the actor to a larger extent, the connection between the goal and scope definition and the actual system model underlying the assessment has to be stressed further. For this we introduce the concept of focal zones assisting in the derivation of the system model from the goal of the actor. This is done via the preferences, priorities and constraints of the actor. The resulting system model is consequently individually tailored to the decision at hand, resulting in the generation and documentation of environmental information that is clearly related to that decision.

Keywords: Decision scope; focal zones; goal and scope definition; minimum system model; specific system model; whole system model

1 Introduction

The definition of system boundaries that clearly identify the system model underlying an LCA study is a task with a difficulty which cannot be underestimated. In the application of the Life Cycle Assessment Methodology, as defined by [2 - 6], the scope of the analysis is to be related to the goal of the assessment. This goal has to be identified from the context in which the study is carried out and from the context in which the generated results will be used.

Hence, for the scope definition, a reasonable compromise that is basically related to the goal at hand has to be found between the two extremes.

- One of these extremes would be to implement a "whole system model" where all links to other production systems, influences on infrastructure, product replacement scenarios, marginal effects on other facilities and so on are to be included in the assessment.
- At the other extreme, we can identify a restriction of the system model to those processes that are directly influenced by the decision to be taken, or to those processes for which the decision maker is liable. We call this approach here the "minimum system model".

1.1 Decision support tool vs. physical model

As discussed in [7] and in the ongoing work of the IEA BCS Annex 31 [8 - 10], tools for the environmental assessment of buildings have to perform a merging of 'two realities'. The actor and his role in the decision making process is one, whereas the building (product) as a part of the technical system forms the other. We take the discussion for application of environmental assessment in the building sector as a background for our research, generally anticipating that the problem is not relevant for the building sector alone.

Whole system model: What we often see in today's LCA studies is a tendency towards a "whole system model" analysis, with use of e.g. system expansion methods to avoid allocation. Obviously, the analysed system may become quite vast and practically limit decision possibilities because of too much data, frequently situated outside the actor's reality. The true goal applied in such studies is to model physical reality in the best possible manner. Thus, the "whole system model" is suited to make LCA a physical model.

Minimum system model: With the "minimum system model" approach, there can be a much lower data demand and a "filling in" with "bad" quality data, as well as a clear focus of results on the actors' reality. This is of course an open door to multiple pollution shifts, which is precisely what LCA was made to avoid in the first place, but it makes LCA a very effective decision support tool.

Obviously, some mid-point should be found where not only actors' reality is modelled in an effective way, i.e. to produce information actually relevant to the decision process at hand, but where physical reality is also modelled well enough not to give too large a bias to this information. Such a compromise solution would also allow for a larger variety of goals than the one called for in the "whole system model":

* Underlying research:
The report [1] underlying this article is the result of a guest research period performed at CSTB Grenoble during autumn '98. During that period, the authors co-operated in the field of actors, with the questions they pose to environmental assessment studies and the link of these preconditions to the system model underlying the assessment.

- An explicit elicitation and documentation of those precise goals and
- a clear mechanism for deriving scope from the goal(s) stated by the actor.

The concept of focal zones is introduced in this paper as a first step towards a fuller implementation of both targets mentioned.

1.2 A paradigm shift

What we suggest here is in full accordance with current LCA definitions, as it leads to a goal-oriented scope. But, as the goal is given by the actor(s), it is very much an actor-oriented approach that will not automatically lead to a "whole system model" scope.

We are aware that this can be perceived as a significant departure from the "LCA as a physical model" paradigm. At the same time, we consider from our own experience in LCA consulting that this new position enforces a better "return on investment" for LCA users while keeping a "low bias" profile, because public opinion and regulatory constraints pushing towards a "life cycle approach" are almost always in play.

As such system models will be defined in close consideration of a decision context, they will deliver information of a kind that can be actually used in the corresponding decision process. In other words, a clearer connection between the question(s) asked and possible actions considered, and the analysed system model, will increase the understanding and usability of the generated results. This suggested position reads as follows:

Starting from the definition of an actor's needs (decision-scope) for actual decision support information, a specific system model can be derived.

2 Developing a Decision-Scope Dependent System Model Approach

2.1 Further definition of the decision scope

The vast amount of actors in the building sector (30+), and consequently the large spectrum of possible applications of LCA, unfortunately makes a direct and definite analysis of the corresponding decision contexts unhandy. Although such lists have been suggested [11], they are mainly of a heuristic value. What we advocate here is a more dynamic approach to scope definition.

Although "decision scope" equates "goals" in LCA vocabulary, the former stresses the fact that goals are relevant to a given actor trying to get specific information to support a decision taking place within a given context, which most probably includes limitations on possible actions. Hence, we suggest the inclusion of the following "chapters" in the definition of a decision scope (or goal):

Priorities Priorities, e.g. environmental policies such as the definition of political goals, are defined by the definition of goals in environmental management or priorities set by the actor.

Preferences Fields of the client's special interest; these may be a special Life Cycle Stage, a certain process (or a set of processes), a precision requirement on certain key emissions or inputs, certain "hot spots" among environmental issues.

Constraints In some cases, due to political, economical, technical, temporal, etc. reasons, some fields of interest have to be considered as "untouchable" – i.e. they cannot be subject to any action resulting from the decision, except the "do nothing" option. Such fields define a constrained domain within which priorities and preferences can be freely applied.

As of now, the effects of both priorities and preferences are acknowledged by the LCA model at the research level at least [12]. Constraints, however, are less often mentioned or applied.

2.2 The concept of focal zones

Thus, in practice, as not all types of decisions can be made on any life cycle step, process, etc., but instead depending on the decision context, the "focus" will not be set equally on all areas of the system model.

1. A system model based on focal zones

We suggest the identification of the zones of various priorities, preferences and mainly constraints within a system model as separate focal zones. A focal zone is defined as:

a system model of part of the physical reality based on part of a given actor's decision scope.

Basically, from the priorities, constraints and preferences, products and processes are identified and assigned to one of three focal zones:

- The primary focal zone,
- a secondary focal zone and
- a non-focal zone.

The derived system model comprises processes that are identified as being part of a primary or a secondary focal zone. With the operational actor context, the extent of these zones will vary. As an example, the primary focus might include the production facilities of company X, whereas supporting services that are not directly influenced by the decision at hand, such as e.g. infrastructure and energy production, are placed in the secondary focal zone.

Consequently, the primary focal zone consists of the processes and activities identified by the decision-maker as prior fields of concern, whereas the secondary focal zone comprises those complimentary processes indirectly influenced by the product or process in main focus. Our approach is also in accordance with modularly defined unit processes. By positioning them either in the primary or secondary focal zone, solely the requirements concerning the resolution and quality of applied data are influenced.

Positioning of processes in the three focal zones is not product-dependent, but solely and entirely dependent on the decision scope. Hence, when regarding different actors assessing the same product, a fluctuation of processes and their positioning will be detectable. Depending on the study at hand, the three focal zones may or may not be present. In [13], for example, a distinction is made between a core balance and a supplementary balance. In the EQuity model [7] only the primary focal zone is included in the system model.

2. Examples from the building industry

In this chapter, we illustrate the rationale behind the concept of focal zones with examples from the building industry. This presentation is based on an economical analysis of this industry from [14].

In the building industry, building producers (paradoxically known as "clients" by most other actors) do not control the overall production process, as they generally rely on designers (architects, engineers, etc.) for the design and contractors to do the actual building. They typically have an even weaker control over subsequent steps of a building's life cycle. Reasons for this are manifold:

- Clients may delegate the real estate management, operation and maintenance (service life / use step) to other actors;
- The later actors generally remain unknown until the building produced is purchased / sold / rented, i.e. after the building has been produced;
- What actually happens during the building's use phase (extending over the coming 50+ years) can only be a guess at best, as buildings are all prototypes.

Hence, the primary focal zone of a building producer will be the programming phase of the design stage, for which he is responsible and where he will be able to specify some of his preferences (technical and environmental) to other actors, under constraints of limited knowledge and control. Obviously, the use step cannot be more than a secondary focus at best and demolition will remain outside his focal zones. It is expected that the same kind of focal zone distribution occurs when analysing a renovation project. In case of a demolition, things become simpler, as only limited information on past steps is required (e.g. material "content" of the building) and these steps will not be subject to decisions.

Clients, developers, real estate agents, designers, engineers and contractors are thus specialised in short-lived, on-site production processes, whereas real estate managers and operators are specialised in continuous, on-site management processes. Obviously, this dichotomy will influence the actors' behaviour - the former being prone to preferring a quicker return on investments than the latter, for instance, and relevant focal zones – the latter being primarily focused on the building-use step, which is a secondary focal zone for the former.

Construction products and machine manufacturers, retailers, etc. are other types of actors in the building industry. They are basically industrial manufacturers without site constraints (besides possibly quarries). Although specialised in construction, their main objects of concern are products and machines, in that order, and not buildings. As they have to produce "objects" that will be used in buildings, they should preferably expand their views in that direction. However, not knowing the client, nor the actual building, its designers and contractors, not to mention the building's use-step operations and actors, both building production and use-life cycle steps will be in the secondary focal zone. The primary focal zone being centred on the construction product's manufacturing step, and possibly extended to distribution through merchants in some cases.

To complete this review, we must mention that other types of actors interfere more or less indirectly with the building industry, although their position will not be discussed here. These include landowners, investors and financial institutions, insurers, networks and services operators, users, public bodies ranging from the EU to municipalities, as well as professional organisations.

3. Resolution and Data Quality in relation to focal zones

In accordance with the actor's focus, it can also be anticipated that the quality of obtainable information varies. This, as

- the responsibility of the actor also enables him to gather relevant high quality data for the process under his decision scope,
- the amount of time available for an analysis of processes in the primary focus will be higher than for processes outside the main interest of the actor.

This leads to a similar spread of interest, focus and resolution. Resolution is here defined as the level of detail in the process tree description; an aggregated process having a very low resolution and a highly detailed chain of processes a high one. A further effect of higher data quality requirements in the main focal area is that the area for which results are supposed to be obtained and actions to be decided coincide with the application of the highest possible quality.

With larger distance from this main sphere of interest or influence of the decision-maker, quality and the resolution of analysis can decrease. This zone of gradually or even abruptly decreasing interest is visualised as a blurred zone of an indifferent interest, called the secondary focal zone.

Aspects outside the decision scope of the actor will not be included in the decision-scope related system model, as decisions will not include aspects that are ruled out as not being relevant by the decision-maker or his clients. Hence, there is a zone that might be included in other contexts, but that is entirely disregarded for the study at hand. This zone of non-interest is here called the "non-focal" zone.

Actor's Context	Focal Zone	Scope	Data Quality	Resolution
Direct interest	Primary	Includes process	High	High
Indirect interest	Secondary	Includes process	Medium	Low to zero (aggregated processes plugged-in)
No interest	Non-focal	Excludes process	Not relevant	Not relevant

Defining and applying focal zones is thus a convenient way to help specify goals and to document their implementation in terms of scope, as separate data quality and resolution requirements for each focal zone can be given.

4. Result interpretation in relation to focal zones

A separate presentation of results in accordance with the focal zones can help the actor in identifying improvement potentials within his/her immediate decision sphere and those potentials in the secondary sphere. The benefit of this segregated result presentation is that decisions in the immediate focal zone can be based on information that is not blurred by the inclusion of aspects of secondary interest. Even environmental information in the other focal zones can be displayed, hence giving the actor an indication on where further improvements concerning the overall product performance can be identified.

Pointing out environmental impacts in the focal zone that is not addressed by the actors main focus may otherwise lead to the impression that the product is best improved by other actors. Applying the concept of focal zones enables one to display both, the environmental impacts related to the decision scope of the actor, and those impacts outside that zone.

3 Conclusion

As neither the well established "whole system model" that is applied to better reflect the physical context of the object of analysis nor a very stringent restriction to a small number processes seems to be appropriate in all application situations, the focal zone concept enables a delimitation according to the actor's decision context. Focal zones allow for the definition and documentation of the various parts of a system model derived from the preferences, priorities and constraints related to the actor's goal, expressed in terms of a decision context in which a decision is to be taken.

A relatively reliable technique for streamlining an LCA is to set data quality requirements for non-dominant sub-processes lower and to enable the inclusion of estimates rather than precise inventory data [15]. As requirements on data quality, resolution, etc. can be different between focal zones, this concept forms a convenient way to include areas of various credibility and criticality to the decision process into the same product assessment without losing this fundamental information when interpreting the results.

As of now, focal zones seem to be an interesting piece for a mechanism still to be developed, that would allow for a clear derivation of a study scope from its goals. Conversely, focal zones can help decide whether given results taken from a database can be used for a new assessment.

In an application to building sector products, the concept of focal zones may aid practitioners in the consideration of the always-unknown future service life and end of life steps. Typical for the building sector is also the often unavoidable mixing of different system levels (product, building, building agglomeration) among the different actors. To put this clearly, the "product" changes with the life cycle stage, and it is not always possible to keep track of products in the life cycle of a building.

Finally,
we would very much appreciate a forthcoming discussion on the issues related to the connection of the goal with the scope definition.

4 References

[1] Trinius, W.; Le Téno, J.F.: Decision-scope Dependent System Models for LCA in the Construction Industry, TRITA-BYMA 1999:2, KTH Building Materials, Stockholm Sweden, March 1999

[2] Fava, J.A.; Denison, R.; Jones, B.; Curran, M.A.; Vigon, B.; Selke, S.; Barnum, J.(Eds): A technical Framework for Life-Cycle Assessment, Society of Environmental Toxicology and Chemistry (SETAC), Vermont USA, Aug 1990

[3] Consoli, F.; Allen, D.; Boustead, I.; Fava, F.; Franklin, W.; Jensen, A.A.; de Oude, N.; Parrish, R.; Perriman, R.; Postlethwaite, D.; Quay, B.; Séguin, J.; Vigon, B. (Eds): Guidelines for Life-Cycle Assessment: A "Code of Practice" SETAC-Europe, Brussels 1993

[4] Lindfors, L.G.; Christiansen, K.; Hoffman, L.; Virtanen, Y.; Juntilla, V.; Hanssen, O.J.; Rønning, A.; Ekvall, T.; Finnveden, G: Nordic Guidelines on Life-Cycle Assessment, Copenhagen 1995

[5] Jensen, A.A.; Elkington, J.; Christiansen, K.; Hoffmann, L.; Møller, B.T.; Schmidt, A.; v. Dijk, F.: Life Cycle Assessment – A guide to approaches, experiences and information sources, Report to the European Environment Agency, Søborg, 1997

[6] Environmental Management – Life Cycle Assessment – Principles and Framework, ISO/FDIS 14040:1997 (E), International Organization of Standardization, 1997, Genève Switzerland, 1997

[7] Le Téno, J.F.: Développement d'un modèle d'aide à l'évaluation et à l'amélioration de la qualité environnementale des produits de construction, Doctoral Thesis, 1996

[8] Russell, P.: Energy Related Environmental Impact of Energy, in: Proceedings of the International CIB Conference on Buildings and the Environment, Paris, June 1997

[9] Lalive d'Epinay, A.; Scheringer, M.; Hungerbühler, K.: An Analysis of Tools for the Assessment of Environmental Impacts of Buildings, in: Proceedings Ecoinfoma 97 "Information and Communication in Environmental and Health Issues", Munich, October 1997

[10] Nibel, S.: Theories and principles in environmental assessment of buildings, IEA Annex 31 work draft document, unpublished 1997

[11] Llewellyn, J.W.; Edwards, S. (Editors): Towards a framework for environmental assessment of building materials and components – BRITE-EURAM project report, BRE 355, 1998.

[12] Huijbregts, M.A.J.: Application of Uncertainty and Variability in LCA – Part 1, in Int. J. LCA 3(5), pp. 273-180, 1998.

[13] Braunschweig, A.; Müller-Wenk, R.: Ökobilanzen von Unternehmungen, Berlin – Stuttgart – Vienna, 1993

[14] Carassus, J.: Production and management in construction – An economic approach, Cahiers du CSTB n°3085, CSTB, 1998

[15] Hunt, R.G.; Boguski, T.K.; Weitz, K.; Sharma, A.: Case Studies Examining LCA Streamlining Techniques, Int. J. LCA, Vol. 3, No. 1, pp. 36-42 (1998)

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